

# OptiLayer



***OptiLayer  
Thin Film  
Software***

***OptiLayer supports all stages  
of the design, characterization  
and production cycle***

***OptiLayer.com***

***OptiLayer GmbH***

## Features of OptiLayer Thin Film Software

The OptiLayer software suite is the fastest, most powerful and comprehensive software tool set in the area of optical coatings. The package software consists of three modules:

- **OptiLayer** facilitates the design, evaluation, error analysis, and computational manufacturing of optical coatings,
- **OptiChar** enables the characterization of single layer films via spectral-photometric and/or ellipsometric data,
- **OptiRE** enables post-production characterization of multilayer coatings on the basis of measurement data.

**OptiReOpt** is a library aimed at a real-time characterization and reoptimization of optical coatings being produced in deposition plants equipped with on-line spectral-photometric and ellipsometric monitoring.

**OptiLayer** utilizes the most up-to-date software solutions and has a unique mathematical kernel designed on the highest professional level.

- **OptiLayer** achieves outstanding performance on any computers running Windows 10 or Windows 11; Windows 7/8 is still supported.
- **OptiLayer** software has a user-friendly interface which makes work pleasant and convenient.
- The Installation process takes only a few minutes.
- **OptiLayer** has a context-sensitive help system and advanced manuals.
- The installation package includes a number of tutorial examples.
- The package includes a large Catalog of materials and substrates and provides direct import from RefractiveIndex.INFO.

## General

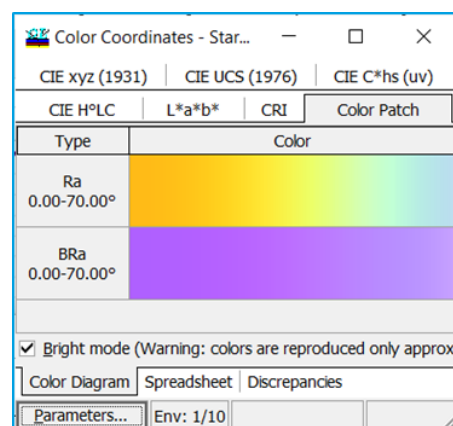
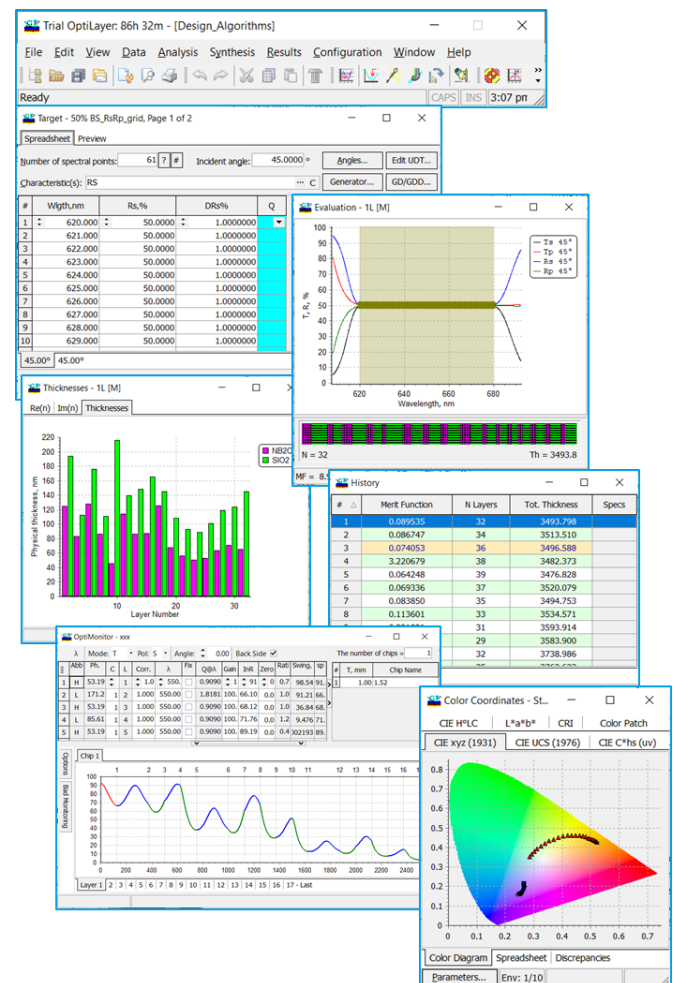
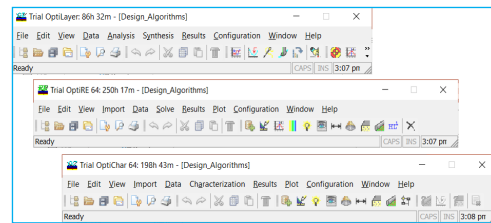
**OptiLayer** software operates in any spectral range and angular range. The number of grid points in spectral and angular ranges is practically unlimited.

For convenience, there are two main modes of the software: spectral and angular. In both modes, targets and measurement data can be specified over both spectral parameter and angular domains.

OptiLayer

OptiRE

OptiChar



Spectral parameters can be specified in nm, Å,  $\mu\text{m}$ ,  $\text{cm}^{-1}$ , eV, keV,  $2\pi/\text{cm}$ ,  $\mu\text{m}^{-1}$ , THz, GHz and g-numbers. Angular parameters can be specified either in degrees or in radians. For X- ray applications it is possible to set grazing incidence angles instead of standard incidence angles.

**OptiLayer** allows designing all types of optical coatings:

- Anti-reflection coatings: narrow band, broad band, single or multiple band, omnidirectional;
  - High reflectors, cold and hot mirrors, dichroic mirrors, chirped and dispersive mirrors;
  - Filters of all types: edge filters, band pass filters, narrow band pass filters, minus filters, notch filters, WDM filters, gain flattening filters;
  - Beamsplitters and polarizers;
  - Absorbers;
  - Rugate and quasi-rugate coatings;
  - Color coatings;
  - Coatings for architecture glass;
- and all other types of multilayers in accordance with desired spectral characteristics.

All modules of **OptiLayer** software store the data for specific problems in separately identified directories without mixing them up. At the same time, there are convenient options that allow the transferring of data files between various directories.

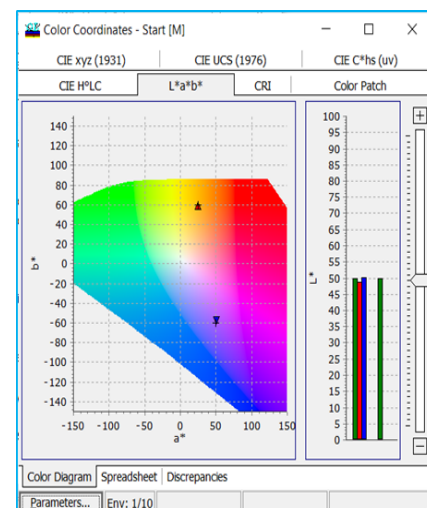
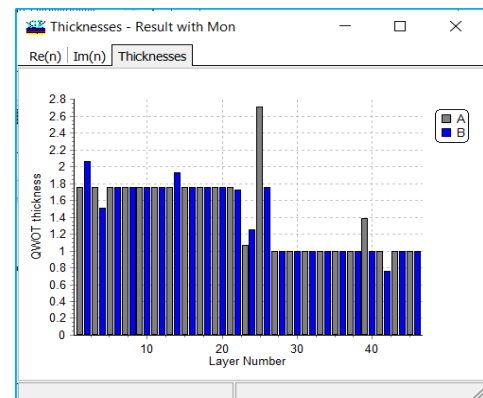
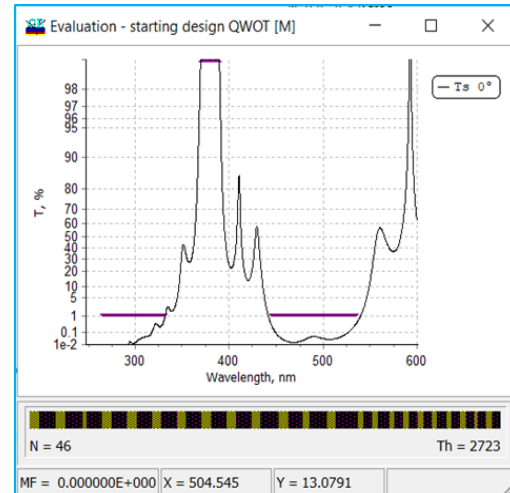
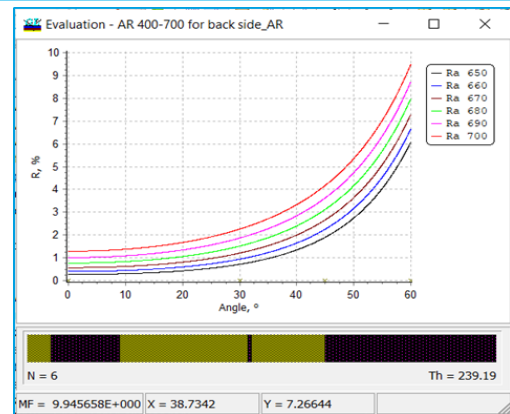
**OptiLayer** provides the design, evaluation and reliable characterization of coatings composed of various materials:

- dielectrics;
- metals and metal-dielectrics;
- conductive oxides;
- semiconductors.

## Input options

All modules of **OptiLayer** software have a set of original editing options which enable convenient and fast input of numerical and symbolic data. These options include:

- linear and nonlinear grid generators,
- column editor allowing fast generating of data in columns;
- copying, inserting and deleting options;
- pages editor allowing generating of large arrays of data specified over spectral and angular do-



mains;

- universal import options allowing easy input of numerical data from two-column data files and from any external ASCII file;
- copy-paste data sets using Windows clipboard.

**OptiLayer** software supports data acquisition from the data files of different formats used in well-known spectrophotometers and ellipsometers. There are also special options for data exchange with many commercial thin film software applications and with the main lens design programs. It is required to push only one button to import data from:

- Perkin Elmer, JCAMP-DX;
- Woollam, Horiba;
- Agilent Cary;
- Semilab - Sopra;
- Sentech;
- SPEKTRUM;
- Bühler Leybold, OptoRun;
- Essential Macleod, FilmStar, TFCalc;
- ZEMAX, CODE V, FRED, OPTIS SPEOS, OpTaLix;
- JASCO;
- Hitachi;
- Zeiss-Optoplex and Zeiss-ThinProcess.

A wide choice of import options makes **OptiLayer** compatible with all commercial and homemade software packages.

**OptiLayer** provides the possibility to carry out calculations taking cone angle and detector line width into account.

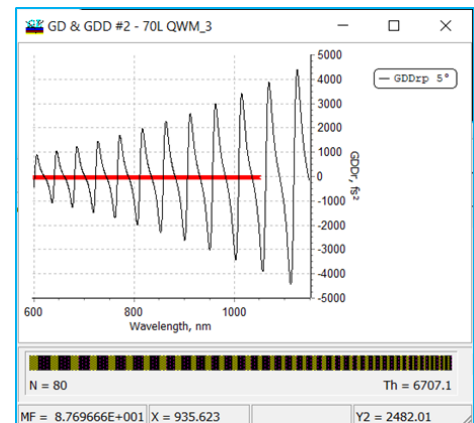
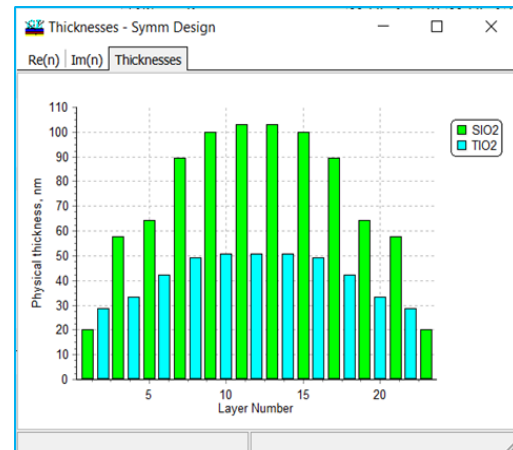
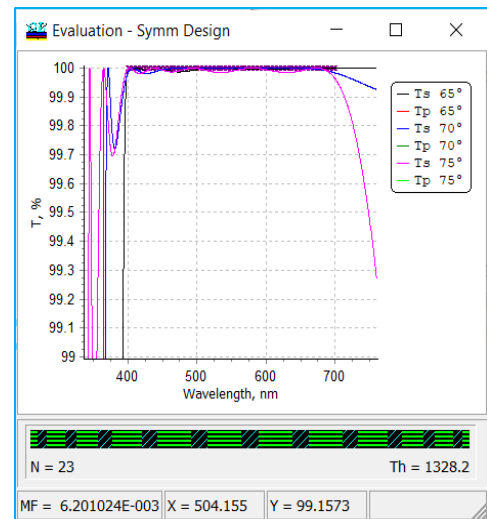
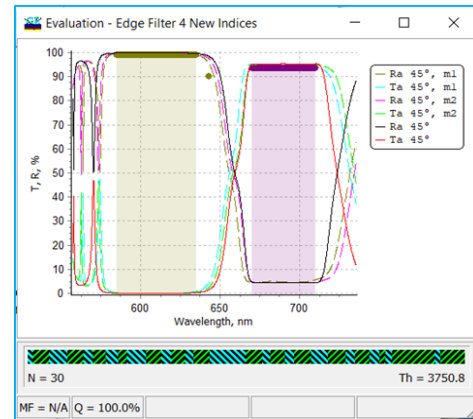
### Graphical options

Graphical options of **OptiLayer** software meet all modern demands. It is possible to:

- control the display and appearance of all chart elements;
- label area, line, and data point elements;
- control the scale and appearance of various types of axes;
- control the positioning and appearance of various titles, footnotes, and legends;
- compare spectral characteristics related to different designs, and much more.

### Output options

Results obtained by **OptiLayer** are presented in a



graphical form and in the form of various reports containing numerical data and detailed text comments related to the data. It is possible to print and save all chart windows and reports. Chart windows can be saved as

- \*.VTC2 files (this format is used by the powerful [OptiLayer](#) graphical add-on [Plot Engine](#)).
- Various graphics formats including BMP, JPG, WMF, PCX, GIF, TIFF, PNG, EPS, SVG, VML and PDF.

Chart data can be saved in Text, XML, HTML, and Microsoft Excel formats. Reports can be saved as ASCII files or exported directly to Microsoft Excel. For easy navigation, Output report windows can represent the data in a hierarchical form and as a plain text.

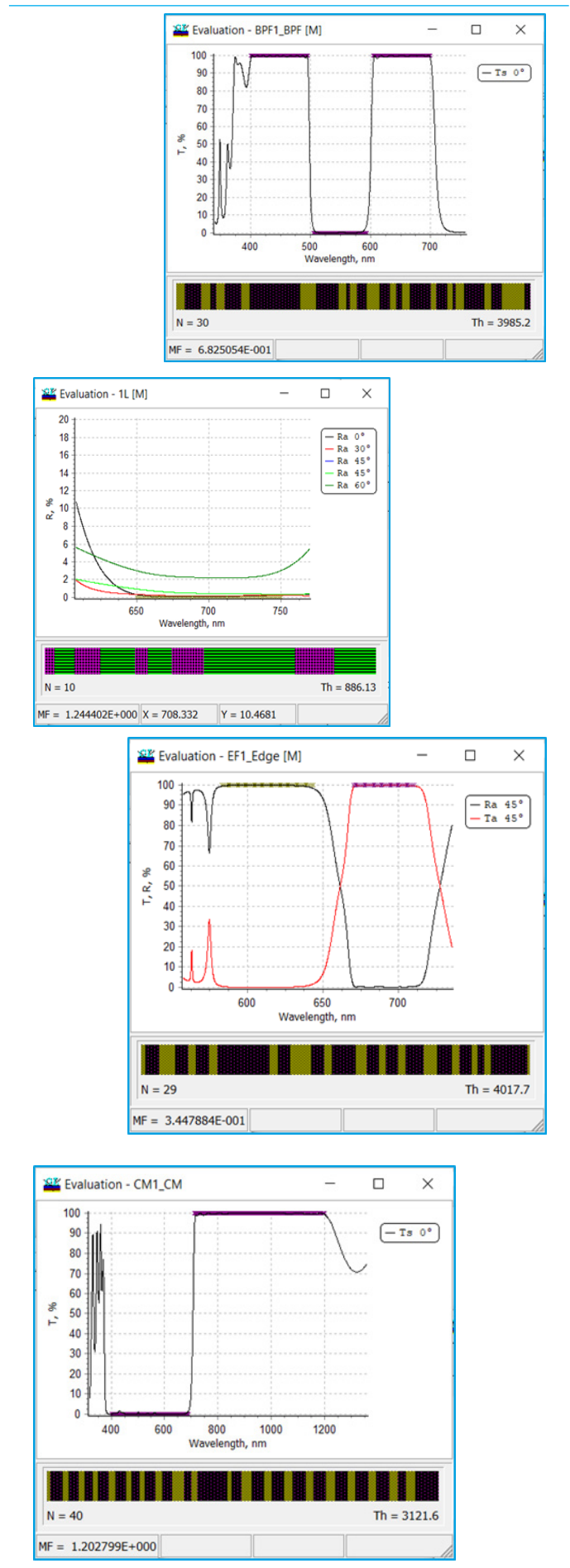
OLE (Object Linking and Embedding) is supported by the powerful stand-alone [OptiLayer](#) utility, [Plot Engine](#). This technology allows one to insert [Plot Engine](#) files directly to your favorite software, for example, to MS Word documents, PowerPoint presentations, CorelDRAW charts, and more.

### Analysis options in OptiLayer

[OptiLayer](#) can evaluate a large variety of optical coating characteristics:

- reflectance, transmittance, absorptance for *s*-polarized, *p*-polarized and non-polarized light;
- phase shifts on reflection and transmission for *s*- and *p*- polarizations;
- differential phase shifts on reflection and transmission;
- group delay (GD) and group delay dispersion (GDD) for the transmitted and reflected light;
- user-defined characteristics, for example, difference between *s*- and *p*-polarized reflectance/transmittance;
- ellipsometric angles  $\psi$  and  $\delta$ ;
- electric field intensity distribution inside the coating;
- U- and g-values;
- admittance diagrams;
- Integral and averaged values;
- Absorptance in separate layers;
- Taper/Wavefront.

It is possible to calculate color coordinates and all other color characteristics of a coating with an ar-



bitrary light source and detector in the reflected or transmitted light of any polarization using almost all existing color coordinate systems:

- CIE XYZ 1931;
- CIE YUV (UCS 1960) and CIE YU'V' (UCS 1976);
- CIE L\*U\*V\*;
- CIE L\*A\*B;
- Hunter Lab;
- Dominant/Complimentary wavelengths and Excitation purity.

OptiLayer provides CIE xyz (1931), CIE UCS (1976), CIE C\*hs(uv), and CIE H°LC color diagrams.

A flexible interface allows switching between color diagrams and spreadsheets containing numerical values of corresponding color coordinates. It is possible to depict trajectories of color coordinates on the diagrams for a specified angular range.

OptiLayer can calculate Correlated Color Temperature (CCT), Color Rendering Index (CRI), and Duv. It is possible to specify up to 14 test samples for CRI evaluation.

Color analyses with CIEDE2000, CIE76, CIE94 (graphic arts), CIE94 (textfiles), CMC 1:1 (1984), and CMC 2:1 (1984) color difference functions can be performed.

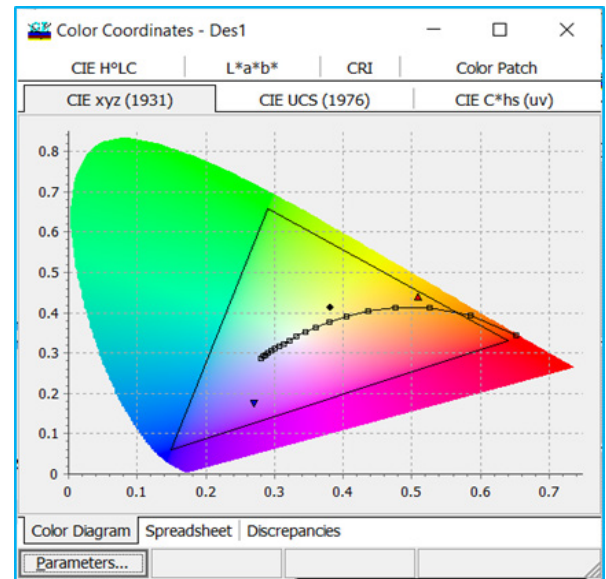
The Color Patch window allows obtaining better understanding on current color properties of the design.

OptiLayer is the only thin film software that can accurately evaluate and design coatings with group delay and group delay dispersion characteristics. It makes OptiLayer an extremely powerful tool in the area of laser related coatings. These options also provide powerful capabilities for thin film WDM technologies connected with 40 Gb/s and Tb/s applications.

OptiLayer allows evaluation of spectral characteristics of a sequence of substrates/media with optional coatings at each boundary between them. Each substrate/medium can be plane-parallel (all reflections are taken into account) or wedged (reflected light is going away from the optical path of the system and is not taken into account).

Evaluation modes of the program are accompanied with a set of other convenient options:

- to average coating characteristics over arbitrary



Color Evaluation Parameters

Characteristic: ☒ Transmittance ☐ Reflectance ☒ Back Reflectance

Polarization: ☐ S-case ☐ P-case ☒ Average

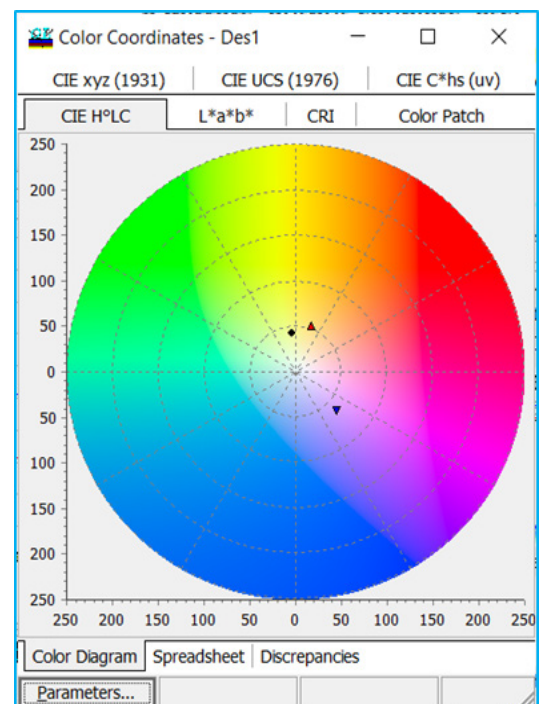
Angle (°): ☐ Range

Display: ☒ Color Target ☐ Target ☐ Ref. White ☒ Design ☐ 100%-Target

Color Diagram: ☐ XYZ Triangle ☒ TV Triangle ☐ Spectral Points ☐ RGB Triangle ☐ Hue and Saturation ☒ Planckian Locus

Anchor: Char: R Pol: A Angle =

Calculate Cancel Help



spectral and/or angular ranges;

- to find minimum and maximum values of various characteristics in specified spectral or/and angular ranges;
- to calculate weighted integral values of spectral characteristics for a set of widely used spectral weight functions or for user-defined weight functions;
- to pick out exact numerical values from the evaluation plots at arbitrary points;
- to change the number of evaluation plots and their chart appearance in the most convenient way;
- to open several independent evaluation windows for plotting coating characteristics in various scales and various ranges.

**OptiLayer** presents:

- plots of the electrical field intensities inside a coating;
- plots of dependencies of refractive index and extinction coefficient on physical/optical thickness;
- refractive index profile in bar diagram form;
- admittance diagrams;
- pulse analysis;
- target specifications, color target specifications, and integral specifications.

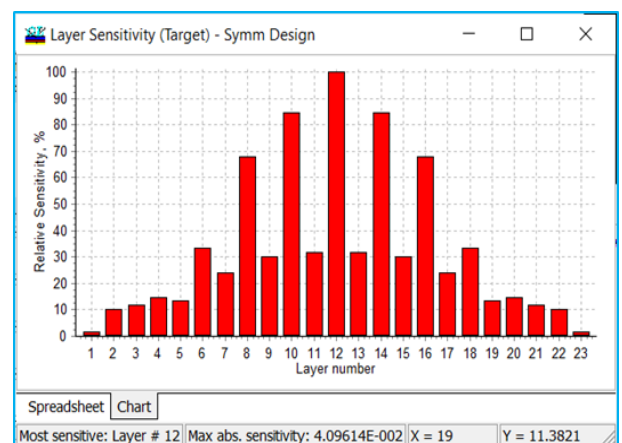
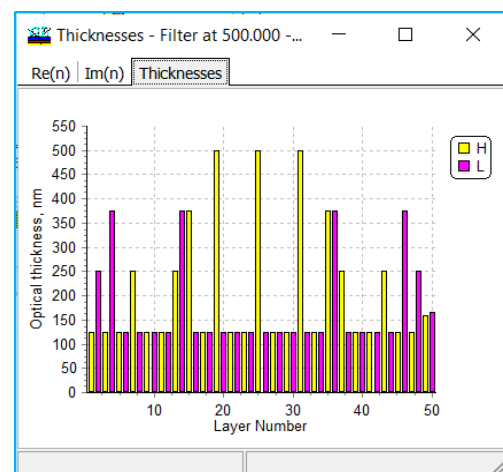
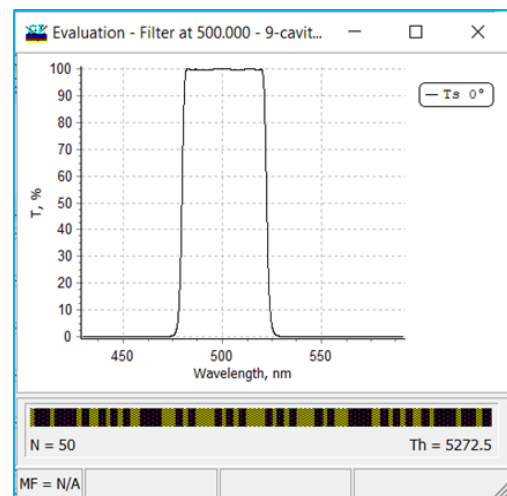
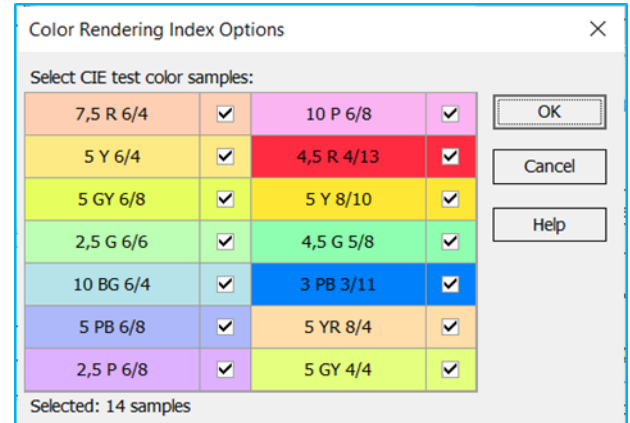
### Pre-production error analysis options

**OptiLayer** has a set of powerful options for the pre-production statistical error analysis of optical coatings. It is possible to evaluate effects connected with:

- errors in layer thicknesses;
- errors in refractive indices;
- inhomogeneity of coating layers;
- interface roughness;
- systematic parameters/deviations connected with monitoring calibration inaccuracies;
- color error analysis including CRI.

**OptiLayer** can evaluate the sensitivity of each coating layer to errors in parameters of this layer and rank coating layers according to their sensitivity to errors.

**OptiLayer** is the only thin film software that has special options for estimating expected production yields of a given design. Special range targets are



used for yield estimations. These targets specify acceptable tolerances of spectral characteristics when various types of production errors are considered.

### Design options of OptiLayer

Outstanding design capabilities of OptiLayer are provided by a flexible combination of various design approaches with the needle optimization technique. OptiLayer incorporates the unique know-how that is inaccessible to other thin film programs.

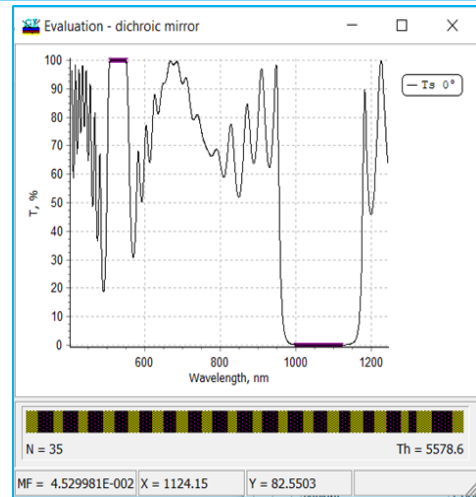
Design modes of OptiLayer can simultaneously exploit targets of five different types:

- Conventional targets;
- Integral targets;
- Color targets;
- Layer absorptance targets;
- EFI (Electric Field Intensity) targets;
- Stress targets;
- User-defined targets.

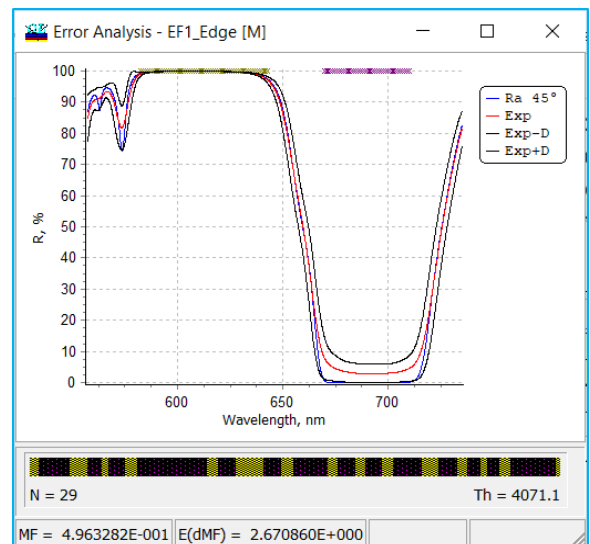
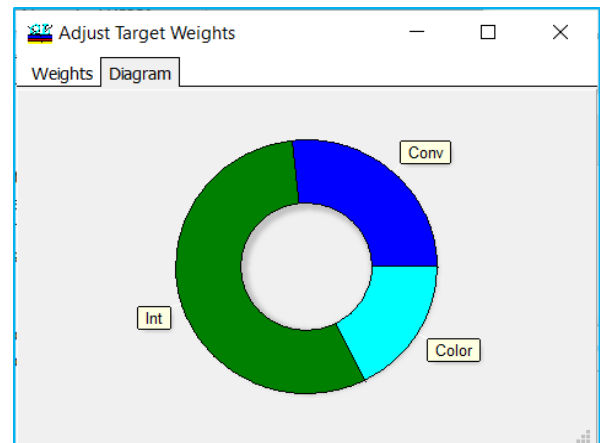
Refinement modes of OptiLayer use the most powerful first, second, and higher order optimization routines. OptiLayer is the only thin film software for which all optimization routines are based on analytic algorithms for computations of gradients and Hesse matrices of merit functions.

The Needle Optimization algorithm is a unique feature of OptiLayer. Needle Optimization is a process in which new layers are inserted into the design being optimized. In automatic mode, the best place to insert a new layer is found automatically. An optimal thickness for the new layer is computed by a special OptiLayer procedure. After the insertion of each new layer, the number of layers in the stack is generally increased by two. The resulting stack is then refined by one of the available optimization algorithms.

Gradual Evolution is a unique synthesis tool of OptiLayer. It can be applied in situations where the total thickness of the design is insufficient to achieve the desired performance or in cases where there is no good starting design. In the Gradual Evolution process, an additional thick layer is automatically inserted in the design when the termination criteria are not satisfied. The Needle Optimization step restarts. This cycle runs until one of the termination criteria such as maximal number of layers, thickness, a specified merit function value) has been satisfied.



Integrals, Values - 4L Res		
#	Name	Value
1	MF Total	1.42786E+002
2	Solar direct T,R,A; As 0° 4L Res	90.809151
3	<As 0°> [400,1200]	60.305730



Gradual Evolution and Needle Optimization generate a set of designs stored in history; therefore it is possible to extract the most practical design solution.

Recently developed Deep Search variants of Needle Optimization and Gradual Evolution are used for designs with excellent performance and limited number of layers. At each iteration, Deep Search tries to perform all possible needle insertions and subsequent optimization one by one. Achieved decreases of the merit function are analyzed and, as a result, the insertion variant providing the largest decrease of the merit function is accepted.

**OptiLayer** assists designers in finding a solution for almost any design problem, meeting challenging target spectral characteristics with the highest accuracy. With a focus on practical issues **OptiLayer** develops a variety of algorithms aimed at the automatic synthesis of feasible design solutions and on the implementation of design tools addressing special classes of design problems.

The Random Optimization algorithm allows obtaining multiple designs with close combinations of numbers of layers, total thickness and merit function values.

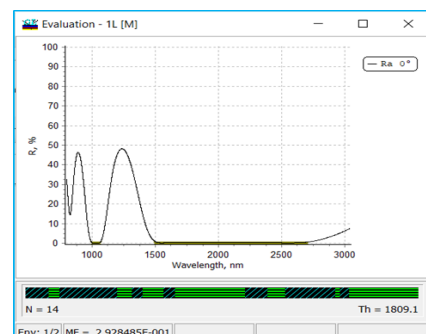
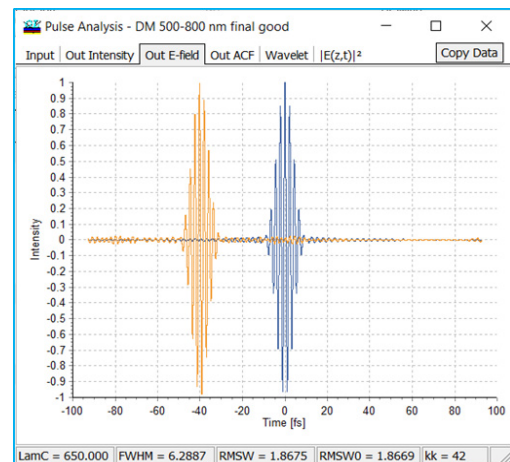
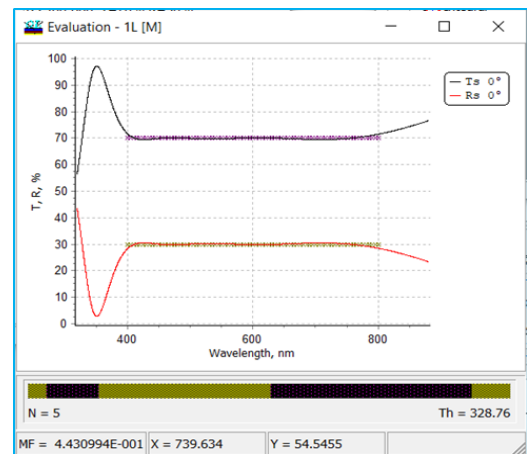
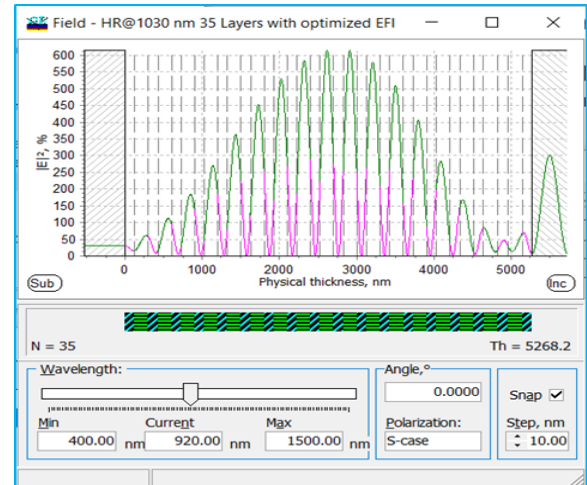
Thin Layer Removal and Design Cleaner procedures allow eliminating thin layers from the designs and reducing the number of layers.

Trapping and Constrained Optimization features imply limits to layer thicknesses.

The Inhomogeneity/Interlayers Refinement option enables coating designs that take the refractive index dependence on layer thickness and the interface roughness of coating layers into account. This option provides new opportunities for the designing of super quality optical coatings for UV-Visible-Near IR spectral regions and coatings for EUV and X-ray applications.

The Sensitivity-Directed Refinement algorithm gives possibilities to synthesize filters consisting of nearly quarter-wave stacks in the case of short-pass and long-pass filters as well as filters blocking sidebands of Fabry-Perot band passes.

Specialized Rugate and Constrained optimization algorithms are powerful tools for designing coatings with very special spectral properties, - for example,



high reflectors with extended transmission zone and reduced sidelobe reflectance ripples.

The Formula Constrained Optimization algorithm enables designing of coatings specified in a design formula format.

A recently developed option permits operating with materials with optical constants dependent on layer thickness.

**OptiLayer** allows designing coatings with specified color target properties:

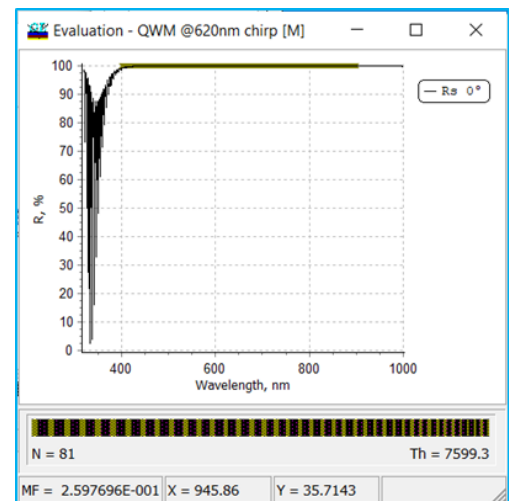
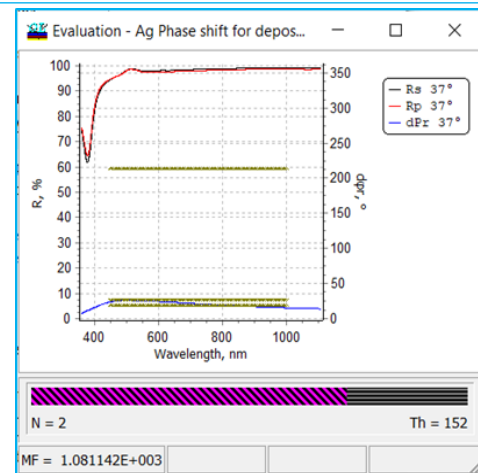
- The target color coordinates may be specified in all existing color coordinate systems;
- In the course of the design process, both light source and detector are taken into account;
- Color diagrams track color coordinates of the current design;
- **OptiLayer** suggests a choice of reference white points and provides an opportunity to create your own reference white points;
- It is possible to specify requirements for minimal relative change of color between some color calculated at a given angle and the current color, and for this purpose the Anchor Color concept is used;
- Color differences are calculated in accordance with chosen formulas.

There is a unique **OptiLayer** option aimed at designing WDM filters. The option combines the most powerful classical design ideas with the specific integer programming optimization approach. The WDM filter option can be also successfully used for designing conventional narrow band pass filters consisting of quasi quarter-wave layers.

**OptiLayer** allows designing stacks – combinations of substrates/media with optional coatings at each boundary between them. For this purpose all design techniques can be used.

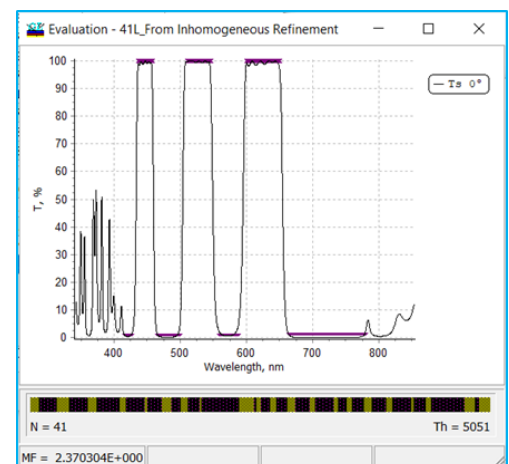
Through the flexible Environment Manager, **OptiLayer** gives an opportunity to design a coating for several environments simultaneously. For each environment, it is possible to define different targets, materials, light sources, detectors, incident media, substrates, the state of the back side, substrate thickness, and the presence of a back-side coating.

The Taper feature allows taking into account thick-



The window contains the following settings:

- Source/Detector/Cone/Integral: WDM
- Color: Data
- Time/Date/Logo: (empty)
- Mode: Units
- Thickness Units: GD & GDD
- Length units: ☒  $\mu m$ , ☐ nm, ☐ Å
- Spectral units: ☒ nm, ☐  $\mu m^{-1}$ , ☐ THz, ☐  $cm^{-1}$ , ☐ eV, ☐ GHz, ☐ 2n/cm, ☐ keV, ☐ g-number
- T, R units: ☐ 0 - 1, ☒ Q - 100%, ☐ dB Attn, ☐ Opt.Density
- Phase units: ☒ Degree, ☐ Radian
- Phase limits: ☐ From -180 to 180, ☒ From 0 to 360



ness non-uniformity in the course of the design process. It is possible to specify up to 32 different environments, which enables one to take distribution of thicknesses in the deposition chamber into account. The option is effective in the case of large area deposition.

**OptiLayer** provides robust versions of all design algorithms. Robust versions of the algorithms allow finding solutions stable with respect to errors in optical parameters of layers. It is possible to specify levels of thickness errors as well as systematic and random offsets in refractive indices.

Symmetrical mode allows designing multilayers symmetrical with respect to the middle point of the coating. This option can be used for immersed cases, when a resulting coating is composed from two parts connected together with optical glue.

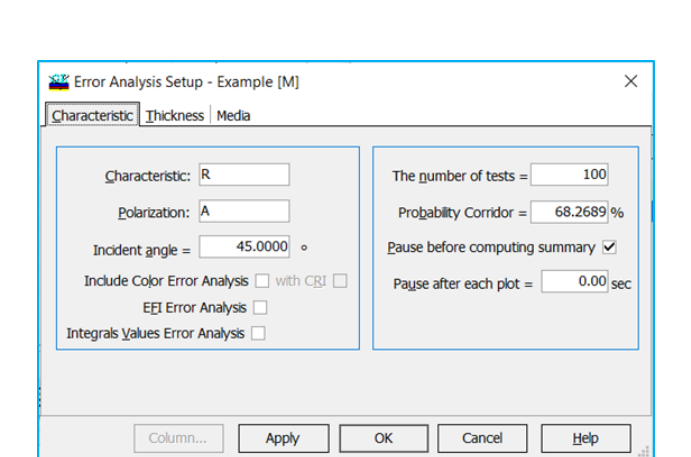
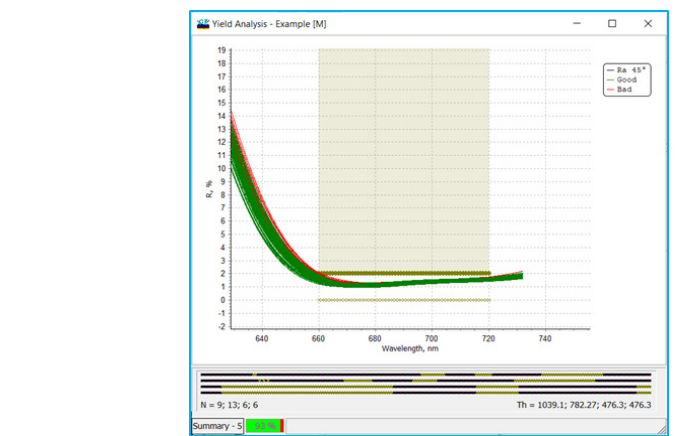
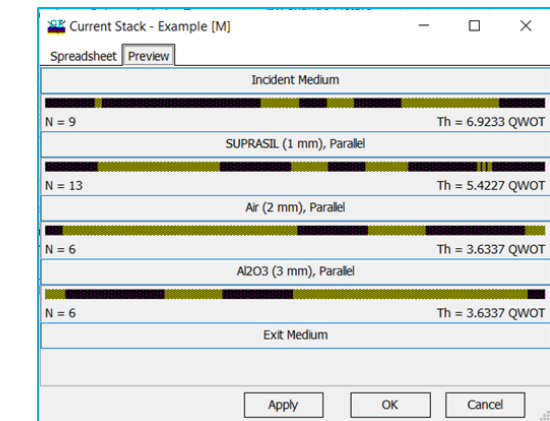
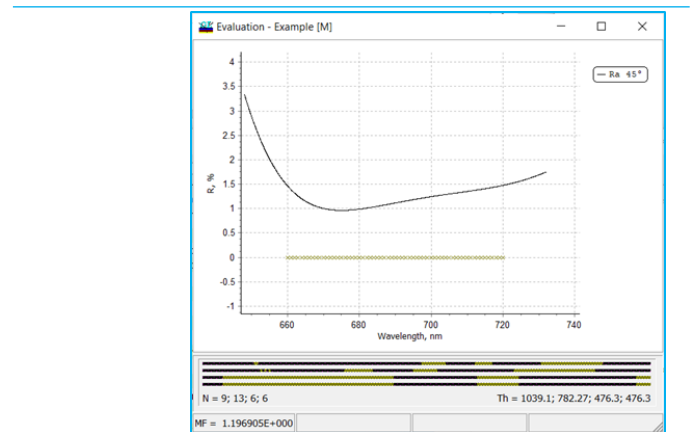
**OptiLayer** supports floating constants for all targets. This is of great importance for design of ultrafast coatings in the case when a constant/parabolic GD/GDD is required. The option is useful in general case when it is necessary to design a coating with constant R/T in some spectral range and the absolute values of this characteristics are not important.

In order to design complicated multi-mirror systems for ultrafast optics, like dispersive mirrors for pulse compressors, **OptiLayer** provides design algorithms optimizing systems consisting of several mirrors.

Variator of **OptiLayer** allows studying interactively how the design performance (spectral characteristics, colors) change with variations of thicknesses and refractive indices of layers and surrounding media.

**OptiLayer** records results obtained at different steps of the design procedure in a special database. This feature allows one to easily return to the previous steps of the design process and to apply other design approaches.

**OptiLayer** uses all new capabilities of modern processors, including multi-core architecture and parallel computations. The computational power of **OptiLayer** design algorithms and the set of design tools are constantly growing and are far superior as compared to the performance of other programs. What **OptiLayer** can do in a few seconds will require



days of computations or will never be achieved at all when using other thin film software programs.

### Optical monitoring options

OptiLayer has a flexible option for generating monitoring spreadsheets corresponding to all types of direct and indirect monochromatic optical monitoring. Convenient graphical interface and a set of auxiliary options help an optical coating engineer to choose monitoring wavelengths for various coating layers. As soon as a monitoring wavelength for a layer is chosen, the respective starting monitoring level, monitoring signal extrema, and swing and termination level are immediately updated in the monitoring spreadsheet.

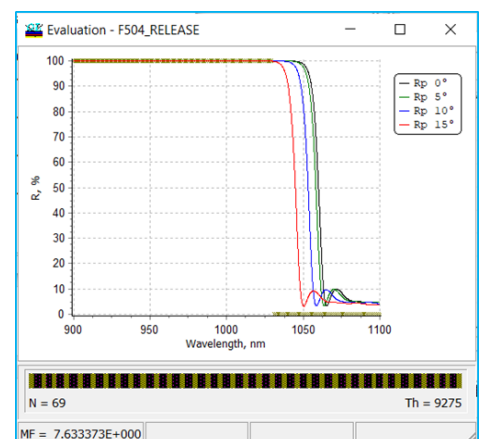
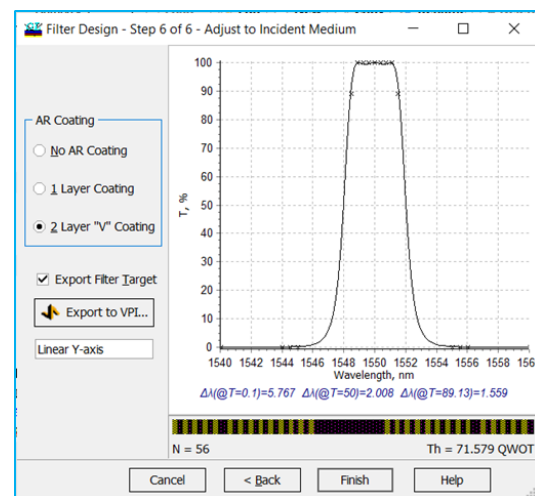
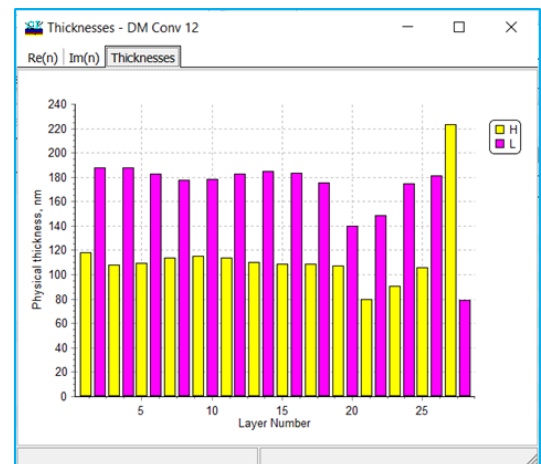
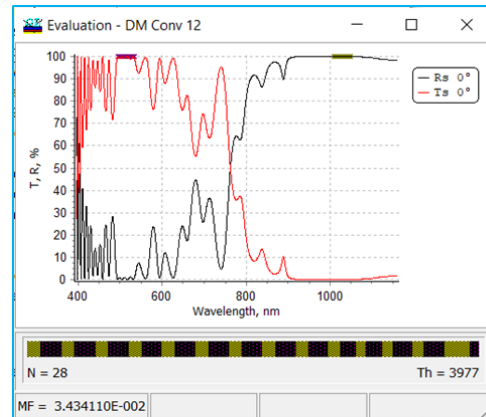
OptiLayer proposes a really breakthrough innovative automatic option for generating monitoring spreadsheets. The new option provides monitoring spreadsheets that :

- Take into account demands for the smallest number of switches between monitoring wavelengths during the deposition process;
- Satisfy specified input and output signal swing values;
- Satisfy specified conditions on signal amplitudes (differences between signal maxima and minima);
- Satisfy conditions on the distance from the trigger point to the next turning point.

The automatic generator of the monitoring spreadsheet is supplemented by the option that allows revealing layers with bad monitoring conditions.

The monitoring spreadsheet generator has many convenient auxiliary options. In particular it is possible to set Gain and Zero values for each layer, to control monitoring light Line Width and shape, and to fine-tune presentation of results.

Monitoring spreadsheets can be created for direct monitoring approaches, when optical monitoring is performed directly on the production sample, or for indirect monitoring with arbitrary witness chip change strategies.



## Computational manufacturing options

Computational manufacturing is the most powerful tool for a pre-production study of design feasibility. Computational manufacturing experiments simulate production runs in the cases when broadband and monochromatic optical monitoring techniques are employed.

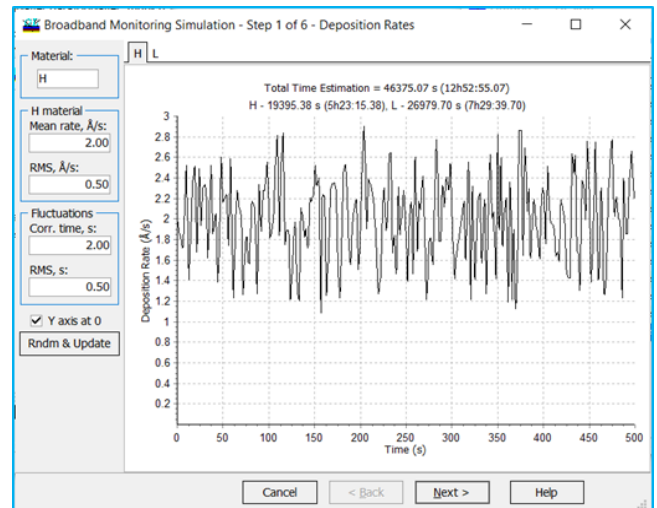
Due to the extremely efficient mathematical algorithms, these experiments can be performed very fast. This opens a way for minimizing test deposition runs required for starting production of new types of optical coatings or for selecting the most stable design solutions. All computational manufacturing settings have convenient and flexible dialogs.

Computational manufacturing options of **OptiLayer** enable estimating expected production yields and revealing design layers where accurate monitoring is especially critical for successful production.

In the course of computational manufacturing experiments, typical error factors responsible for the inaccuracies of deposition processes can be simulated. These factors include:

- Instabilities of deposition rates;
- Errors in terminating layer depositions (shutter delays);
- Deviations of layer refractive indices inside a deposition chamber from their theoretical values;
- Inaccuracies of refractive index wavelength dependencies;
- Inhomogeneities of deposited layers;
- Noise in measurement on-line data;
- Fluctuations of monitoring signals in time;
- Calibration drifts of monitoring devices.
- Some layers can be excluded from the optical monitoring (if they are controlled, for example, by time or using quartz crystals);
- Some layers can be excluded from the production if the deposition process assumed pre-deposited samples.

**OptiLayer** provides an option to simulate production of WDM filters and narrow band pass filters of quarter-wave structure controlled with turning point optical monitoring.



Broadband Monitoring Simulation - Step 2 of 6 - Parameters Deviations

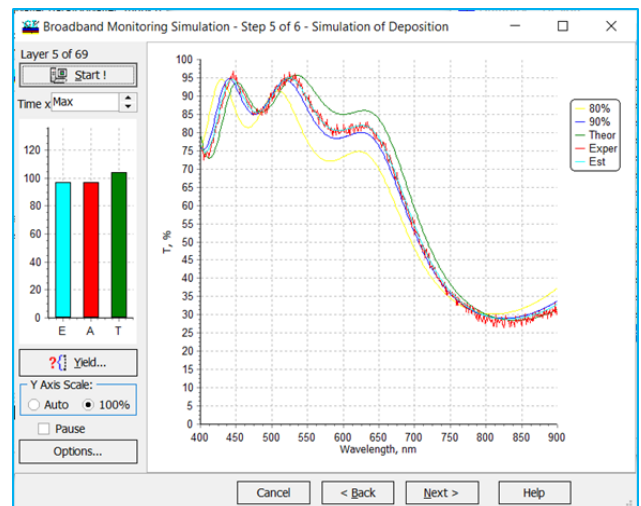
Systematic and Random Deviations:

#	Abbr	Material	Re(n) Syst.Dev.	Re(n) Random Dev.	Syst. Inh. (%)
1	H	Ta2O5 15.12.2005	0.0100	0.0000	0.000
2	L	060216_02 SiO2	0.0000	0.0050	0.000

Exclude design layers from BBM and from Produced coating:

#	Physical Thickness	Abbr	Exclude	RMS Relative Thickness Error, %	Production
1	116.065	H	<input type="checkbox"/>	0.000	<input checked="" type="checkbox"/>
2	154.220	L	<input type="checkbox"/>	0.000	<input checked="" type="checkbox"/>
3	92.957	H	<input checked="" type="checkbox"/>	0.000	<input checked="" type="checkbox"/>
4	128.080	L	<input type="checkbox"/>	0.000	<input checked="" type="checkbox"/>
5	103.784	H	<input type="checkbox"/>	0.000	<input checked="" type="checkbox"/>
6	160.871	L	<input type="checkbox"/>	0.000	<input checked="" type="checkbox"/>
7	115.443	H	<input type="checkbox"/>	0.000	<input checked="" type="checkbox"/>
8	167.372	L	<input type="checkbox"/>	0.000	<input checked="" type="checkbox"/>
9	116.425	H	<input type="checkbox"/>	0.000	<input checked="" type="checkbox"/>
10	166.461	L	<input type="checkbox"/>	0.000	<input checked="" type="checkbox"/>
11	114.503	H	<input type="checkbox"/>	0.000	<input checked="" type="checkbox"/>

Mean shutter delay = 0.080 s Shutter delay RMS = 0.035 s ☒ Use Chips distribution



It is possible to perform computational manufacturing for indirect monitoring, with an arbitrary strategy of witness chip changes. Mixed monitoring approaches can also be considered, in particular, in the cases when some layers are controlled with quartz crystals or by time.

### Characterization options of OptiChar

The **OptiChar** module of **OptiLayer** software is for the optical characterization of single thin films on the basis of spectral photometric and/or spectral ellipsometric data. Measurement data from all widely used spectrophotometers and ellipsometers (Agilent Cary, Perkin Elmer, Woollam, etc.) as well as from two-column data files and from any ASCII file can be easily imported to **OptiChar**.

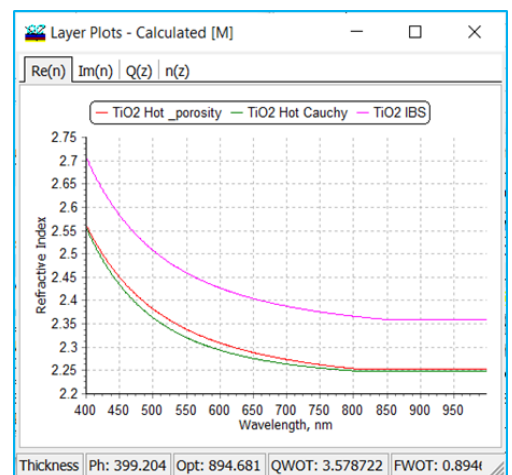
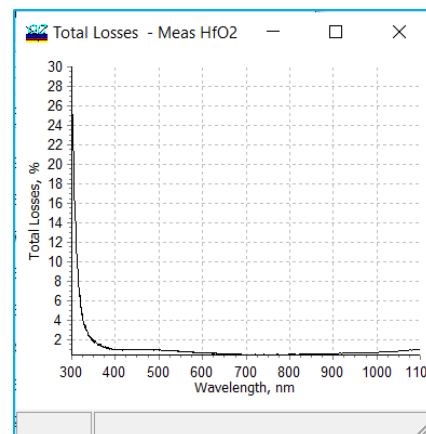
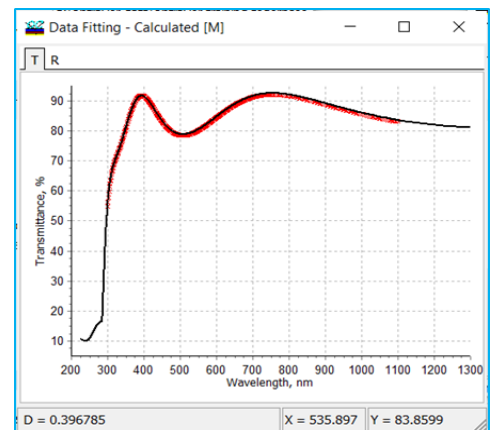
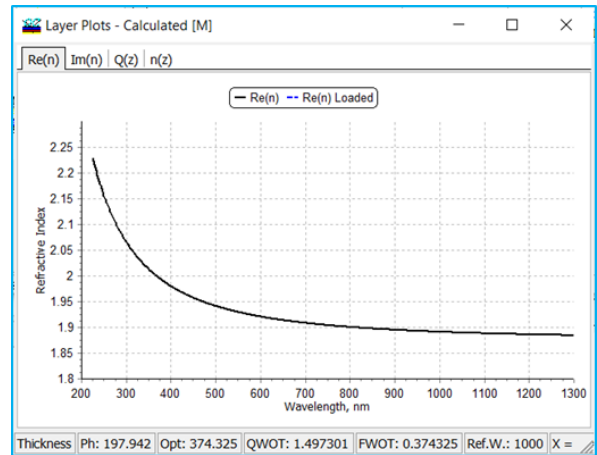
**OptiChar** provides Cauchy and Sellmeier models for description of wavelength dependencies of the refractive index as well as exponential and Sellmeier models for dispersion behaviors of extinction coefficients.

It is possible to specify the limits for thin film parameters according to *a priori* information about optical parameters of the investigated film.

The Layer Refinement option allows refining the results of the characterization procedure when the input measurement data are slightly changed or when a good approximation to the film parameters is already available.

**OptiChar** and **OptiRE** provide a unique non-parametric model for wavelength dependencies of refractive indices and extinction coefficients. This non-parametric model of **OptiChar/OptiRE** is especially useful for complicated characterization problems, when wavelength dependencies of optical constants cannot be described by simple models. The model can be applied for the characterization of thin metal films, metal-dielectric composites, ITO, TCO films, etc. This model should be applied in cases when characterization is performed in broadband spectral ranges.

Two options of **OptiChar**, Bulk Inhomogeneity and Surface Inhomogeneity, allow studying dependencies of layer refractive indices on the coating thickness coordinate. In the simplest cases, it is possible to find a degree of bulk inhomogeneity and thick-



ness of surface overlayer. Studying more accurate thickness dependencies of optical constants is also possible.

The porosity option and the mixture option allow considering the investigated thin film in the frame of effective medium theories. The porosity option allows determination of film packing density. The mixture option helps one to find ratios of the materials forming the thin film.

In the case of ellipsometric characterization, depolarization factors may be taken into account. This provides an opportunity to use measurements taken without special preliminary preparation of thin film samples.

OptiChar allows characterizing not only thin layers but also substrates. The Substrate Characterization option provides a choice of the same set of models as for thin films.

Total losses plots presenting 100%-R-T data help to make conclusions about the presence of absorption in films as well as to estimate the accuracy of measurement data.

It is possible to compare on the same plot optical constants obtained by the characterization process with optical constants taken from the Catalog or from any problem directory. Direct import from RefractiveIndex.INFO is implemented.

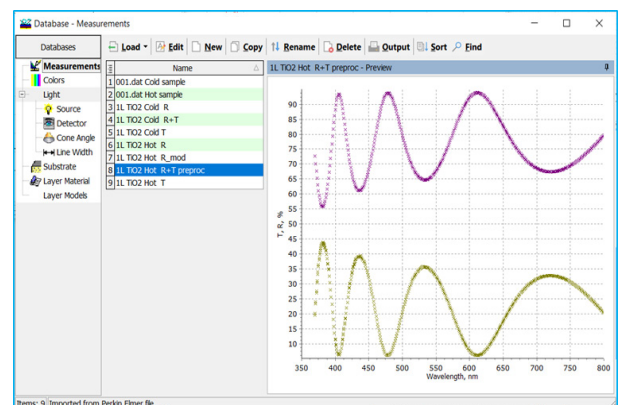
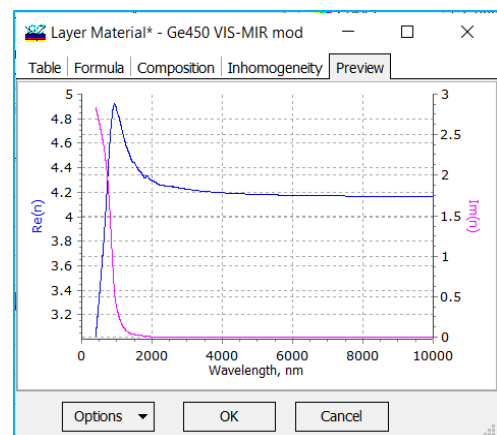
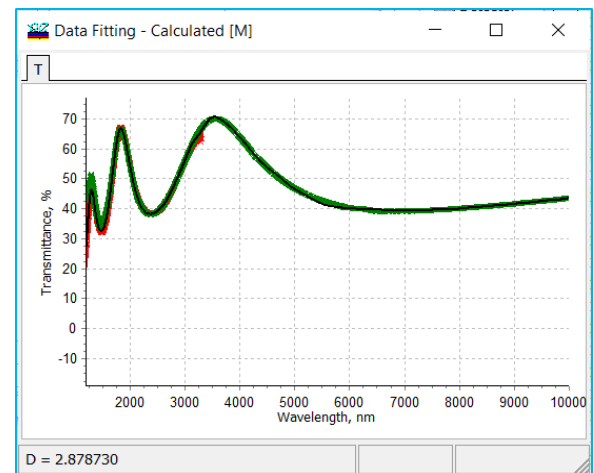
The obtained optical constants can be saved in the layer materials database for further use.

Partial Discrepancies plots show the deviations between experimental and model data. These plots are especially useful in the case of ellipsometric characterization because the delta angle typically varies in the wide angular ranges.

In OptiChar/OptiRE it is possible to take cone angle and line width into account.

OptiChar allows flexible operating with measurement data sets:

- The Modify Measurements and Add to Loaded options allow combining different data files;
- The Preprocess Measurements Data option allows transformations of the measurement data loaded to the memory, cutting data from questionable spectral ranges, decreasing the number



Output - Fitting

View type: Editable View

Layer models:  
 Re(n) model: Norm.Disp.  
 Im(n) model: UV-VIS  
 Bulk inhomogeneity: Schroeder, delta = -3.72184 %  
 Surface inhomogeneity: N/A

Substrate models:  
 Re(n) model: Loaded: Table - Linear interpolation  
 Im(n) model: Loaded: Table - Linear interpolation

The number of angular pages in the measurement data file = 4

Angular page	Wavelength points	# of Measurement chars
1	431	1
2	401	1
3	61	1
4	21	1

Output page # 1, Incident angle = 1E-005 deg

#	Wlngth,nm	Ta,exp	Ta,model	Dis
1	370.000	72.7628	72.0743	0.6885
2	371.000	70.1615	69.2890	0.8725
3	372.000	67.7445	66.7275	1.0169
4	373.000	65.2542	64.4269	0.8273
5	374.000	63.0276	62.4061	0.6215
6	375.000	61.0520	60.6716	0.3803
7	376.000	59.4345	59.2219	0.2126
8	377.000	58.1530	58.0505	0.1025
9	378.000	57.1426	57.1487	0.0061
10	379.000	56.3002	56.5066	0.2064
11	380.000	55.8572	56.1145	0.2573

Fitting

of spectral points, setting tolerances, and normalizing data with respect to the substrate data;

- The Remove a gap option allows to remove non-informative or noisy spectral data (for example, the O-H absorption range).

### Characterization and reverse engineering options of OptiRE

OptiRE is intended for the post-production characterization of optical coatings based on spectral photometric and/or ellipsometric data. Post-production measurement data from all widely used spectrophotometers and ellipsometers (Agilent Cary, Perkin Elmer, Woollam, Horiba, Hitachi, JASCO, Sentech, etc.) as well as the data from arbitrary ASCII files can be easily imported to OptiRE.

It is also possible to analyze on-line broadband and monochromatic measurement data recorded in the course of optical coating production by respective monitoring devices. Special OptiRE options provide input of on-line broadband measurement data recorded after depositions of subsequent coating layers (Multi-Scan Measurements option) and on-line monochromatic measurement data (Response Data option).

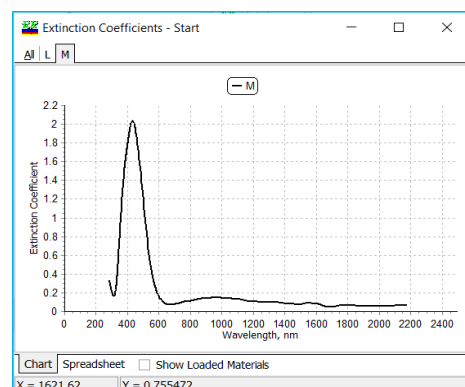
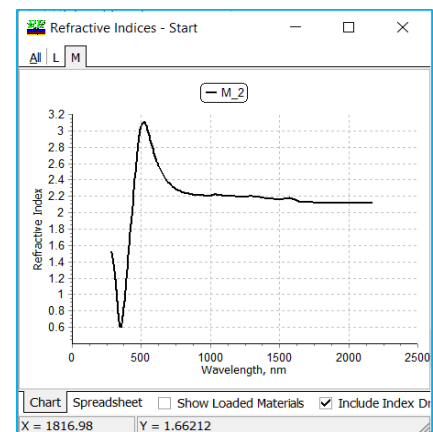
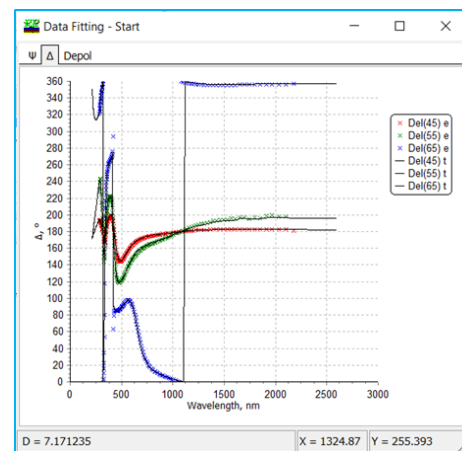
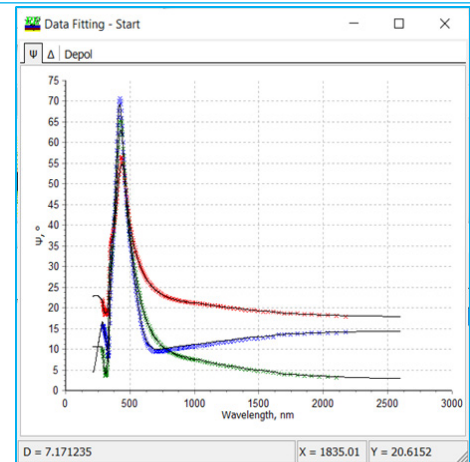
OptiRE allows to analyze multi-scan measurements in the case of indirect broadband optical monitoring as well.

OptiLayer allows one to import and store log files recorded by broad band monitoring devices. The new option BBM Movie Data allows analyzing these files in order to study specifics of broad band monitoring procedures.

OptiRE provides a Color Measurements database. Measured color coordinates can be introduced and compared with target color coordinates.

OptiRE calculates U- and g-values based on measurement data related to produced coatings.

Post-production characterization of produced optical coatings is an important element of modern design-production chains because it provides a feedback for the deposition process. The main purpose of OptiRE is to discover systematic and random errors in layer parameters of deposited coatings and thus to raise the quality of optical coating produc-



tion.

**OptiRE** provides a variety of coating models and algorithms specially developed for characterization of multilayer coatings.

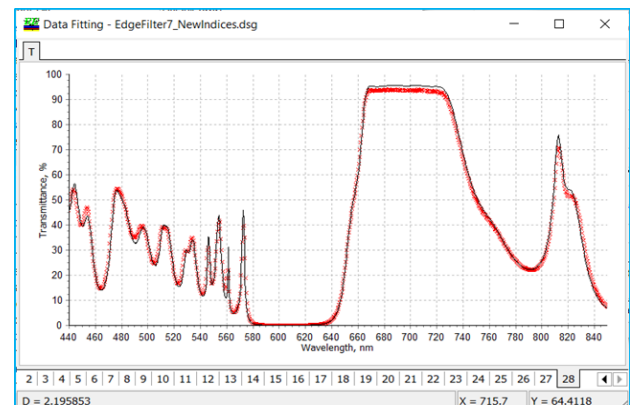
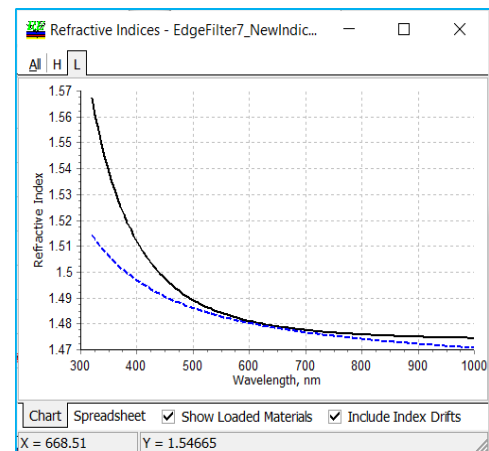
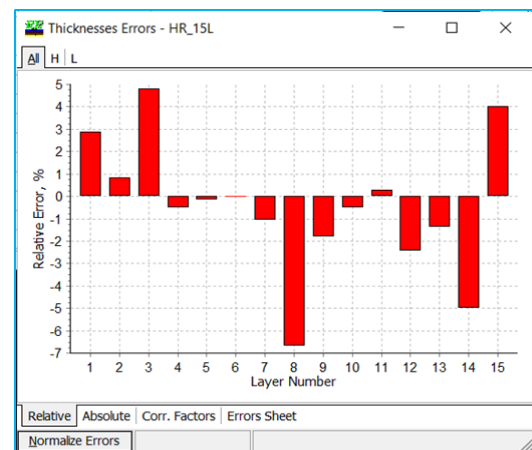
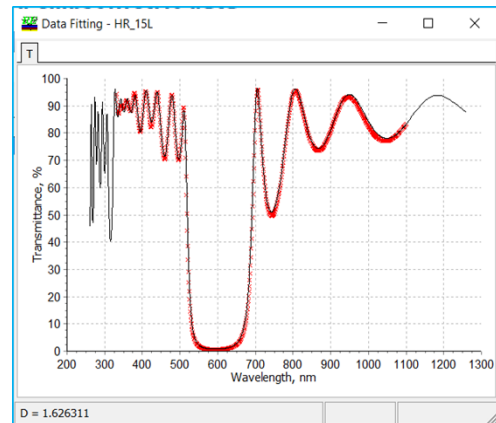
- The Systematic Errors option of **OptiRE** performs a search for systematic errors in layer thicknesses. Results obtained with this option are presented in the form of “correction factors” to the theoretical thicknesses of layers of each particular material. This option is especially convenient for the calibration of time monitoring, quartz crystal monitoring or indirect optical monitoring.
- The Indices Correction option is intended for the correction of nominal layer refractive indices specified in a theoretical coating design. For various reasons layer refractive indices in a multilayer stack may deviate from respective indices determined on the basis of characterization of single layer samples and then used in optical coating designs.

The Indices Correction option allows:

- Determination of offsets of actual refractive indices from nominal ones;
- Determination of linear and exponential drifts of actual refractive indices with respect to coating coordinate;
- Correction of wavelength dependencies of layer refractive indices;
- Correction of wavelength dependencies of extinction coefficients.
- The Random Errors option performs a search for random errors in layer thicknesses. This search is a multi-parametric inverse problem whose solution may be unstable and non-unique. Special mathematical algorithms of **OptiRE** allow obtaining reliable results.
- The Quasi-Random Errors option combines the features of the Systematic Errors and Random Errors options. These algorithms take into account possible correlations between errors in thicknesses of layers of each particular material.

**OptiRE** allows investigating inhomogeneity of layers of any particular or all used materials.

- Advanced **OptiRE** options allow simultaneous search for errors in layer thicknesses as well as layer refractive indices and degrees of inhomogeneity.



geneity, and can be applied in the most complicated reverse engineering problems;

- Because all spectrophotometric devices feature some instability, and measurement data can drift after performing a measurement calibration, **OptiRE** can apply a special autocorrection procedure to correct for possible errors associated with this effect.

The results obtained by **OptiRE** algorithms are presented in graphical form and in the corresponding spreadsheets. All obtained results are also presented in reports and can be saved or easily exported to Microsoft Excel. These results may include errors in layer thicknesses, corrected refractive indices and extinction coefficients, degrees of inhomogeneity, and achieved fittings of experimental data by model data.

**OptiRE** allows flexible operation with measurement data sets. Modify Measurements, Add to Loaded and Preprocess Measurements Data options allow combining different measurement data, transforming the measurement data, cutting the data from undesired spectral ranges, decreasing the number of spectral points, setting tolerances, and normalizing data with respect to the substrate.

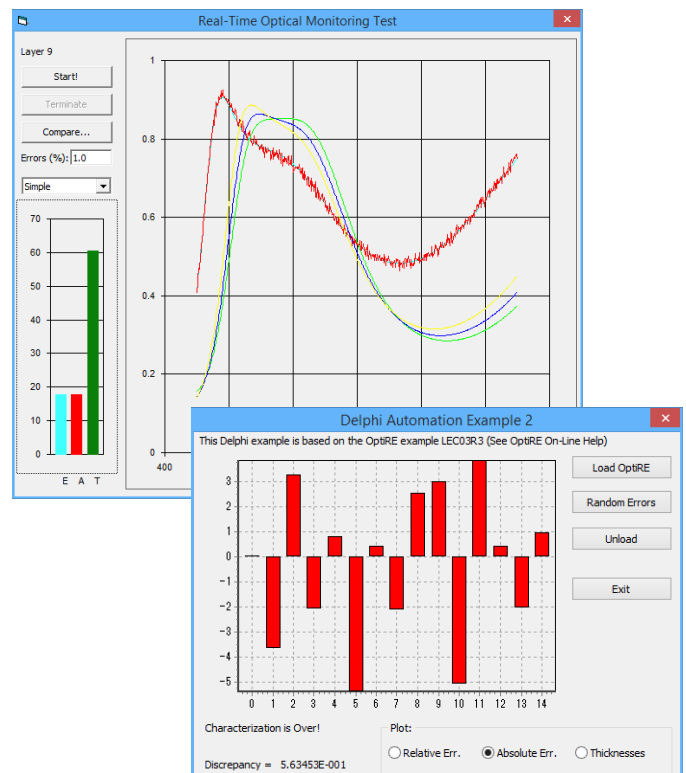
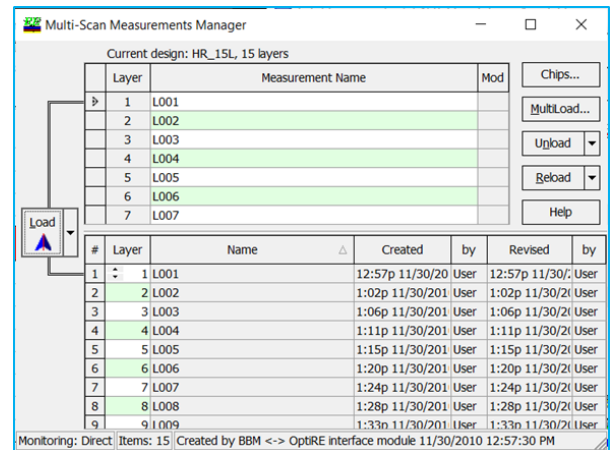
## COM Automation

**OptiRE** supports the modern software technology called Automation. This enables incorporating **OptiRE** in any production control software. Due to this technology, **OptiRE** can be involved in the on-line control of manufacturing process.

It is possible to call **OptiRE** functions and get results back from any other program. The only requirement is to use a tool supporting COM Automation technology. It is possible to use:

- Visual Basic;
- Visual C++, C#, Embarcadero C++;
- Delphi;
- Java;
- Matlab;
- LabVIEW.

The **OptiLayer** package is supported by corresponding examples in Visual Basic, Delphi and LabView which help optical coating engineers to start implementation of **OptiRE** into their design-production



chains.

## OptiReOpt library

OptiReOpt is specifically developed for a real-time support of optical coatings production in deposition plants equipped with on-line monitoring devices.

OptiReOpt can be used for control of the layer thicknesses in the course of the deposition process. It can be also used for the on-line compensation of manufacturing errors.

OptiReOpt is arranged as a DLL (Dynamic Link Library) and therefore is able to be embedded into any environment supporting DLL calls. It has both 32 and 64-bit versions.

Among these environments are:

- Microsoft Visual Studio version 6.0 (C++, Visual Basic) and Microsoft Visual Studio 2005-2019 (C++, C#, Visual Basic for .NET);
- Borland, Embarcadero C++ Builder (any version) and Borland Delphi (version 5.0 and higher);
- Embarcadero Delphi 2007, 2009, 2010, XE, XE2-XE10;
- LabVIEW versions 5.xx - 8.xx and later;
- Java at MS Windows platforms.

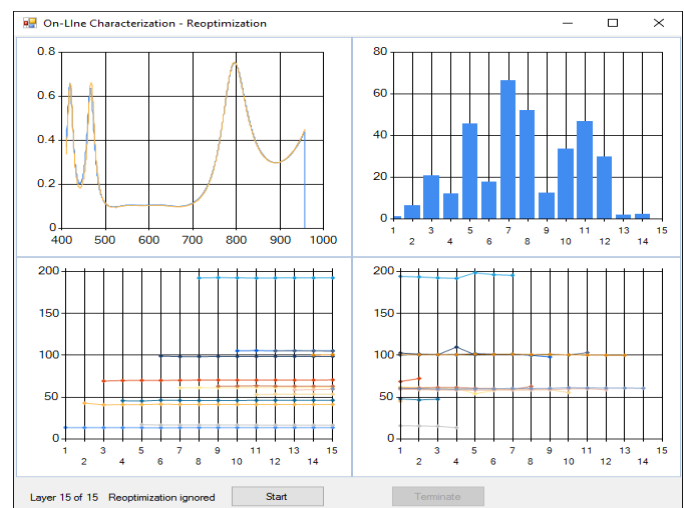
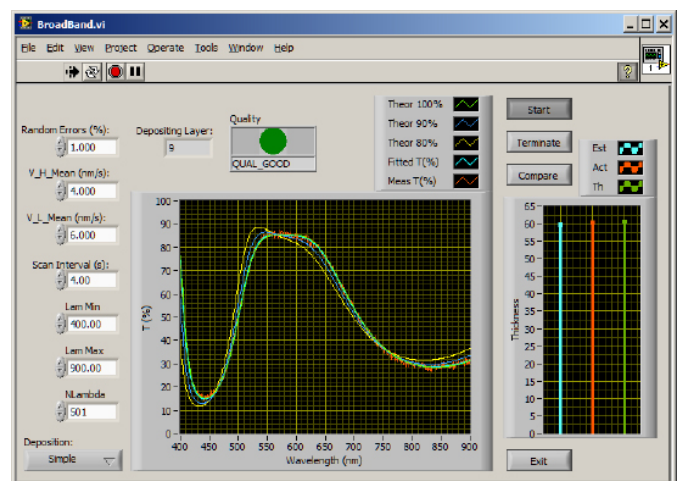
Additional flexibility is achieved by COM interfaces that can be used for calling functions of the OptiReOpt module. COM interfaces add parameters checking which simplifies the development of a deposition process controlling software.

OptiReOpt can be used by any customer's control software supporting DLL calls at practically all deposition plants with any type of on-line spectral photometric and spectral ellipsometric devices. Special attention is paid to providing convenient OptiReOpt use in the LabView environment, because this software tool is often used for the implementation of deposition control software.

OptiReOpt DLL functions provide access to unique OptiLayer mathematical routines and, due to this fact, OptiReOpt exhibits an outstanding computational efficiency. Even in the case of coatings with dozens of layers computations are so fast that reliable determination of parameters of deposited layers and reoptimization of parameters of remaining layers does not require interrupting a deposition process.

```
Project1 - Form1 (Code)
(General)
(Declarations)

End Sub
Private Sub Form_Load()
    ' Initialize Charting control
    Ch.Plot.UniformAxis = False
    Ch.Plot.DataSeriesInRow = True
    ' Clear all data
    Ch.DataGrid.SetSize 0, 0, 0, 0
    ' Load initial data
    Dim Res As Integer ' Variable for storing return result
    Set OV = New OptiReOpt ' Create Library object (empty)
    ' Specify Log file location, Multiprocessor support (no/yes)
    OV.Initialize App.Path & "\Test.log", SingleProcessor ' or Multiprocessor
    ' Check version of the OptiReOpt, this example requires version >= 5.26
    If Val(OV.Version) < 5.26 Then
        Err.Raise vbObjectError + 513, , "OptiReOpt version should be >= 5.26"
    End If
    ' Check if the hardware key is present and registered
    If Not OV.HWKeyPresent Then
        MsgBox "Hardware key not present or not registered." & Chr(13) & _
            "Use OptiReOpt Key Activation utility to register and to check the key!"
    End If
    ' Enter some general settings. Most of them can be overridden later
    Res = OV.LoadOnlineConfig(L_RI, RI_PERCENT, TH_QWOT, DATA_TRANS, MODE_TRIANGLE,
    OR_CHECK OV, Res
    ' Load substrate from OptiRe OUT file
    Res = OV.LoadOnlineMaterialFile(0, App.Path & "\Quartz_Disp.OUT")
    OR_CHECK OV, Res
    ' Load HFO2 from OptiRe OUT file (dispersion table)
    Res = OV.LoadOnlineMaterialFile("H", App.Path & "\HFO2_Mod.OUT")
    OR_CHECK OV, Res
    ' Load SiO2 from OptiRe OUT file (Cauchy formula)
    Res = OV.LoadOnlineMaterialFile("L", App.Path & "\SiO2_Mod.OUT")
    OR_CHECK OV, Res
    ' Load theoretical design from OptiRe OUT file
    Res = OV.LoadTheoreticalDesignFile(nLayers, App.Path & "\Qwm_151.out")
    OR_CHECK OV, Res
    ' Simple (no deposition strategy) test as default
    ' This will call LoadMeasurements in OnClick event handler
    StrategyCombo.ListIndex = 0
End Sub
```





## OptiLayer GmbH

phone: +49 089-997-59-603

web site: [www.optilayer.com](http://www.optilayer.com)

e-mail: [support@optilayer.com](mailto:support@optilayer.com)

### **Distributors:**

---

#### North America West

“Coherent Technologies” Dr. John Bellum  
8505 Cherry Hills Rd NE, Albuquerque, NM 87111 USA  
phone: (505) 514-8584

e-mail: [jbellum@coherenttechnm.com](mailto:jbellum@coherenttechnm.com);

web site: [www.coherenttechnm.com](http://www.coherenttechnm.com)

---

#### North America East

“JK Consulting”, Dr. Jennifer Kruschwitz  
33 Elmore Road, Rochester, NY 14618 USA  
phone: (585) 271-8861; cell phone: (585) 370-6539

e-mail: [jkconsult@kruschwitz.com](mailto:jkconsult@kruschwitz.com);

web site: [www.kruschwitz.com](http://www.kruschwitz.com)

---

#### Europe

“Langbein Kolb Consulting”, Dr. Irmgard Langbein, Dr. Burkhard Kolb  
Hauptstrasse 145a, D-76344, Eggenstein-Leopoldshafen, Germany  
phone: +49 721 78169215; fax: +49 721 78169215

e-mail: [i.langbein@gmx.de](mailto:i.langbein@gmx.de)

---

#### Israel

“OptiLayer GmbH”

Watzmannring 71, 85748 Garching, Germany

phone: +49 089-997-59-603

e-mail: [support@optilayer.com](mailto:support@optilayer.com)

---

#### Japan

“Caywan Office Inc.”, Mr. Yasunari Onizaki  
2-3-3 Midorigaoka Okazaki-city, Aichi, 444-0806, Japan,  
phone: +81-908321-7341; fax: +81-564-54-5830

e-mail: [y-onizaki@caywan.com](mailto:y-onizaki@caywan.com);

web site: [www.caywan.com](http://www.caywan.com)

---

#### China

“OPTurn Company Ltd.”, Dr. Honggang Gao

R607, Yingshi Building 49-3, Suzhoujie Street,  
Beijing, 100080 China

phone: +86 10 6252 7842, fax: +86 10 6252 7843

e-mail: [sales@opturn.com](mailto:sales@opturn.com);

web site: [www.OPTurn.com](http://www.OPTurn.com)

---

#### India

“Fiber Optics Services”, Mr. Pravin Joshi

428, Prestige Industrial Estate, Bawadi Lane, Orlem,  
Marve Road, Malad (W), Mumbai 400 064 India

phone: +91 22 28802653; fax: +91 22 28803653

e-mail: [info@foservice.com](mailto:info@foservice.com); web site: [www.foservice.com](http://www.foservice.com)

---